4.2 A Robust Radiation Detector for Rapid Waste Characterization

Technology Need

This project directly addresses several needs for radiation detection including: portable sensors for use on robotic systems for waste and facility characterization; and field deployable equipment for rapid characterization of radionuclides in soil, groundwater, debris, equipment, and process effluents. The chemical vapor deposition (CVD) of a diamond coating on a Cadmium Zinc Telluride (CZT) solid state detector yields a sensor that is impervious to extremely hazardous environments such as corrosive chemicals and high radiation fields. The thin diamond coating detectors are excellent for measurement of alpha and low energy beta particles and since diamond has very low dark currents, they can be expected to operate in ambient light. Standard use of separate handheld gamma ray and alpha particle detectors are inadequate due to excessive worker exposure, high expense of operating these detectors due to long times to cover large areas and the labor costs. Commercial solid state detectors are available for alpha particle measurements but these devices are not solarblind or impervious to corrosive chemicals and high radiation fields.

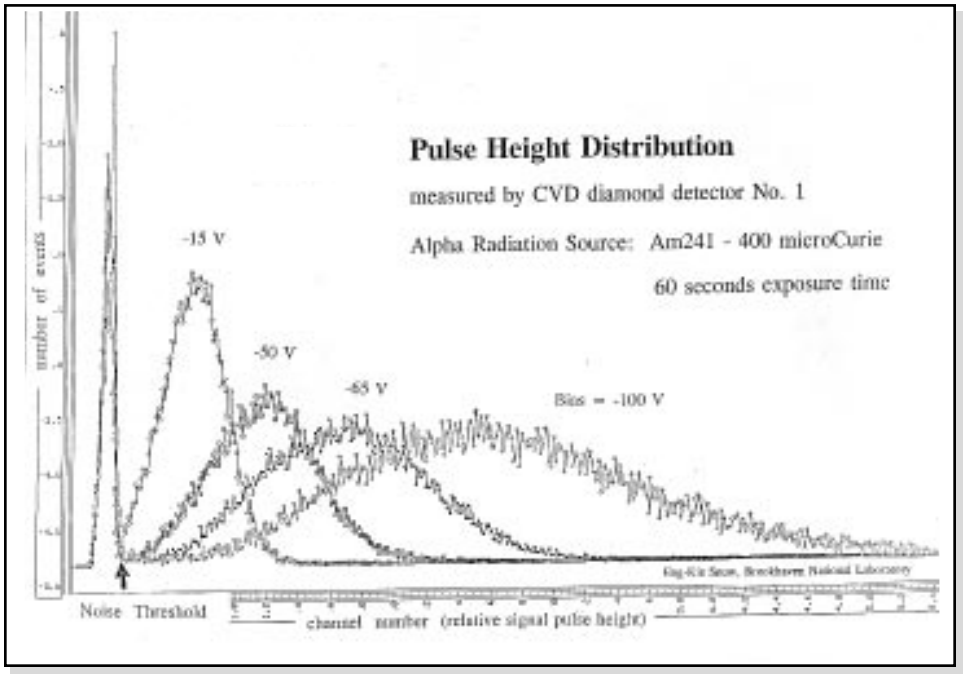

Figure 4.2-1 Pulse Height Distributions measured by a Brookhaven National Laboratory/Northrop-Grumman-made CVD Diamond Detector under 60 second exposure to 400 microCurie ^{241}Am alpha radiation

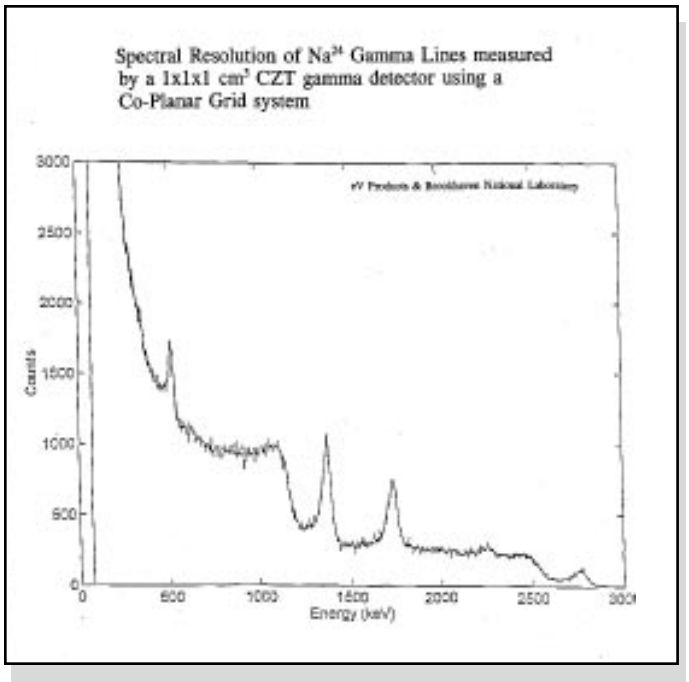

Figure 4.2-2 Spectral resolution of Na^{24} gamma lines measured in a 1x1x1 cm^3, eV-manufactured CZT detector with co-planar grid system: The gamma line at 1.3686 MeV is fully developed; the second gamma line at 2.7540 MeV is too energetic for a 1cm-thick CZT wafer (hence, the low efficiency/peak intensity); the pertaining pair-production & double-escape peak appears prominently at 1.734 MeV

Technology Description

To take advantage of the superior properties of diamond in this project, the conventional front electrode of the Standard Solid State detector is replaced by a p-type, boron-doped CVD diamond layer, so that only the diamond, and no metal layer or coating, is exposed to harsh environments.

CZT has been identified recently as being ultimately superior to CdTe with regard to gamma detection properties. To improve spectral resolutions at higher gamma energies, a recently invented co-planar grid (CPG) technology may be applied.

Benefits

Robust, miniaturized radiation sensors can be engineered to robotic systems to eliminate worker exposure during surveying of walls, floors, ceilings, process equipment or debris.

Radiation sensors engineered to robotic systems are expected to lower surveying costs by more than a factor of ten by eliminating the need for survey and survey support team in the field and by cutting the time for characterizing large areas by over a factor of five by running robotic systems 24 hours a day.

Chemically robust and radiation-hardened sensors can be deployed into highly restricted facility areas and directly into waste and debris, allowing unique determination of the radiation levels at these sites.

Collaboration/Technology Transfer

This collaborative project is making use of Northrop-Grumman's plasma-enhanced CVD diamond reactor, as well as their expertise in diamond-growing and vacuum-brazing of diamond films to other materials. The project will also benefit from a collaboration with the N-G radiation detector group and the company's potential for nuclear detector commercialization.

The project (NJIT) is taking advantage of an existing BNL-New Jersey Institute of Technology collaboration between the BNL Principal Investigator and a NJIT Professor in photoluminescence and radiation damage in microelectronics, while making use of a BNL-owned laser and CCD camera installed at NJIT for that purpose.

As soon as the persistent problem with bulk polarization is resolved, a patent application will be filed for a CVD diamond alpha dosimeter. A second patent application on a complete alpha-beta-gamma detector system is planned, pending a successful development of a composite CVD-diamond/CZT device. These patents provides a basis for technology transfer to private industry, with Northrop-Grumman holding the primary license right.

Accomplishments

- Experimental results indicate that the distribution broadening occurs primarily due to a polarization effect which seems to stop, or at least to slow down substantially, after 11 minutes of continuous exposure under 150 V bias voltage while the pulse height distribution remains well-isolated from the noise background. If results prove reproducible, a diamond detector can be readily used as an alpha particle dosimeter.
- Analysis of gamma spectroscopic performance, with and without the CPG technique, has been conducted on CZT wafers manufactured by three different companies.
- Analysis of current transport and carrier trapping in CVD diamond from photo conductive (PC) current measurements has been carried out at BNL to improve the diamond detector performance and, in particular, to suppress the polarization effect.

TTP Information

Robust Radiation Detector for Rapid Waste Characterization technology development activities are funded under the following technical task plan (TTP):

TTP No. CH353001 "A Robust Radiation Detector for Rapid Waste Characterization"

Contacts

Eng-Kie Souw
Principal Investigator
Brookhaven National Laboratory
P.O. Box 5000, Building 820 M
Upton, NY 11973-5000
(516) 344-5407

Richard Baker
Technical Program Officer
USDOE-Chicago Operations
9800 S. Cass Ave
Argonne, IL 60439
(708) 252-2647

Bibliography of Key Publications

Souw, E.K., C. Szeles, N.M. Ravindra, F.M. Tong. *Proceedings from* TMS *Conference On Transient Thermal Processing*, Anaheim, CA (February 1996).